

We claim:

1. A process for rendering a polyamine-epihalohydrin resin storage stable, comprising:

5 treating a composition containing a wet strength polyamine-epihalohydrin resin, the composition comprising a solids content of at least 15 wt% and including CPD-forming species, with at least one enzymatic agent under conditions to at least one of inhibit, reduce and remove the CPD-forming species to obtain a gelation storage stable reduced CPD-forming resin so that the composition containing the reduced CPD-forming  
10 polyamine-epihalohydrin resin when stored for 24 hours at 50°C, and a pH of about 1.0 releases less than about 250 ppm dry basis of CPD.

2. The process according to claim 1, wherein the composition containing the reduced CPD-forming polyamine-epihalohydrin resin when stored for 24 hours at 50°C, and a pH of about 1.0 releases less than about 50 ppm dry basis of CPD.

15 3. The process according to claim 1, wherein the treatment conditions comprise a temperature of from about 20°C to 60°C.

4. The process according to claim 3, wherein the treatment conditions comprise a temperature of from about 20°C to 40°C.

20 5. The process according to claim 1, wherein the treatment conditions comprise a reaction time of from about 30 minutes to about 96 hours.

6. The process according to claim 5, wherein the treatment conditions comprise a reaction time of from about 2 hours to about 12 hours.

7. The process according to claim 1, wherein the treatment conditions comprise a pH of from about 2.5 to about 9.

25 8. The process according to claim 7, wherein the treatment conditions comprise a pH of from about 7 to about 9.

9. The process according to claim 8, wherein the treatment conditions comprise a pH of from about 6 to about 8.5.

30 10. The process according to claim 1, wherein the ratio of at least one enzymatic agent to polyamine-epihalohydrin resin (dry basis) is from about 1:1600 to about 1:1.5.

11. The process according to claim 10, wherein the ratio of at least one enzymatic agent to polyamine-epihalohydrin resin (dry basis) is from about 1:160 to about 1:4.

12. The process according to claim 1, wherein the ratio of at least one enzymatic agent (active enzyme, dry basis) to polyamine-epihalohydrin resin (dry basis) is from about 0.04:1600 to about 0.04:1.5.

13. The process according to claim 1, wherein the solids content is 15 to 50 wt% active solids, the treatment conditions comprise a temperature of from about 0°C to about 35°C, a reaction time of from about 4 to about 24 hours, a pH of from about 6.9 to about 7.9, the ratio of at least one enzymatic agent to polyamine-epihalohydrin resin (dry basis) is from about 1:20 to about 1:8.

14. The process according to claim 1, wherein the at least one enzymatic agent is selected from the group consisting of an esterase, a lipase, a protease or a combination thereof.

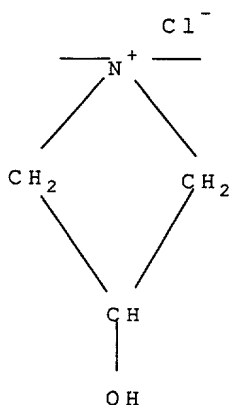
15. The process according to claim 1, wherein the at least one enzymatic agent is a protease in the subtilisin group.

16. The process according to claim 1, wherein the at least one enzymatic agent has esterase activity.

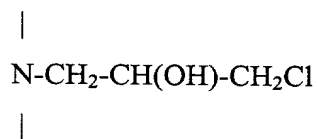
17. The process according to claim 1, wherein the at least one enzymatic agent is produced from a microorganism selected from the group consisting of *Bacillus licheniformis* (Swiss-Prot Accession Number: P00780), or *Bacillus amyloliquifaciens* (P00782), and *Bacillus lentus* (P29600).

18. The process according to claim 1, wherein the at least one enzymatic agent is ALCALASE.

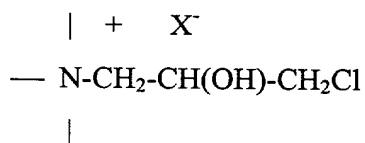
19. The process according to claim 1, wherein the resin is characterized by the presence of the functionality represented by the formula:



20. The process according to claim 1, wherein the resin is characterized by the presence of the functionality represented by the formula:



21. The process according to claim 1, wherein the resin is characterized by the presence of the functionality represented by the formula:



wherein  $\text{X}^-$  is an anion.

22. The process according to claim 1, wherein, at least one of simultaneously with, prior to or subsequent to the treating a composition containing polyamine-epihalohydrin resin to obtain a reduced CPD-forming resin, the resin is contacted with at least one microorganism, or at least one enzyme isolated from the at least one microorganism, in an amount, and at a pH and temperature effective to dehalogenate residual quantities of organically bound halogen.

23. The process according to claim 22 wherein the at least one microorganism, or at least one enzyme isolated from the at least one microorganism is a hydrogen halide lysase type dehalogenase.

24. The process according to claim 22 wherein the at least one microorganism, or at least one enzyme isolated from the at least one microorganism comprises at least one of *Arthrobacter histidinovorans* (HK1), and *Agrobacterium radiobacter* (HK7).

25. The process according to claim 22, wherein the at least one microorganism comprises a mixture comprising at least one of *Agrobacterium radiobacter* (HK7) and, *Arthrobacter histidinovorans* (HK1).

26. The process according to claim 1, wherein, simultaneously with the treating a composition containing polyamine-epihalohydrin resin to obtain a reduced CPD-forming resin, the CPD-forming resin is contacted with at least one microorganism, or at least one enzyme isolated from the at least one microorganism, in an amount, and at a pH and temperature effective to dehalogenate residual quantities of organically bound halogen.

27. The process according to claim 26, wherein the treatment conditions comprise a reaction time of 48 hours or less.

28. The process according to claim 26, wherein the temperature of from about 20°C to 35°C.

29. The process according to claim 26, wherein the treatment conditions comprise a pH of from about 6.5 to 8.0.

32. The process according to claim 26 wherein the ratio of at least one enzymatic agent to polyamine-epihalohydrin resin (dry basis) is from about 1:1600 to about 1:1.5.

30. The process according to claim 26 wherein the at least one microorganism, or at least one enzyme isolated from the at least one microorganism is a hydrogen halide lysase type dehalogenase.

31. The process according to claim 26 wherein the at least one microorganism, or at least one enzyme isolated from the at least one microorganism comprises at least one of *Arthrobacter histidinovorans* (HK1), and *Agrobacterium radiobacter* (HK7).

32. The process according to claim 26, wherein the at least one microorganism comprises a mixture comprising at least one of *Agrobacterium radiobacter* (HK7) and, *Arthrobacter histidinovorans* (HK1).

33. The process according to claim 26 wherein the treatment conditions comprise a reaction time of 48 hours or less, a temperature of from about 20°C to 35°C, a pH of from about 6.5 to about 8.0 and the ratio of at least one enzymatic agent to polyamine-epihalohydrin resin (dry basis) is from about 1:1600 to about 1:1.5 and the at least one microorganism comprises a mixture comprising at least one of *Agrobacterium radiobacter* (HK7) and, *Arthrobacter histidinovorans* (HK1).

34. The process according to claim 1, wherein, simultaneously, prior to or subsequent to the treating a composition containing polyamine-epihalohydrin resin to obtain a reduced CPD-forming resin, the resin is treated to reduce at least one of epihalohydrins, epihalohydrin hydrolysis by-products and organic halogen bound to the polymer backbone.

35. A process for preparing a paper product, comprising:

treating a composition containing wet strength polyamine-epihalohydrin resin, the composition comprising a solids content of at least 15 wt% and including CPD-forming species, with at least one enzymatic agent under conditions to at least one of inhibit, reduce and remove the CPD-forming species to obtain a gelation storage stable reduced CPD-forming resin, and forming a paper product with the reduced CPD-forming polyamine-epihalohydrin resin, so that a paper product, when corrected for adding at about a 1 wt% addition level of the reduced CPD-forming resin, contains less than about 250 ppb of CPD.

36. The process according to claim 35, wherein the paper product, when corrected for adding at about a 1 wt% addition level of the reduced CPD-forming resin, contains less than about 50 ppb of CPD.

37. The process according to claim 35, wherein the solids content is 15 to 50 wt% active solids, the temperature of the reaction is from about 0°C to about 35°C, the reaction time is from about 4 to about 24 hours and the pH of the reaction is from about 6.9 to about 7.9, the ratio of at least one enzymatic agent to polyamine-epihalohydrin resin (dry basis) is from about 1:20 to about 1:8.